REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	June 5, 2002	Final Report 01/01/01 - 12/31/01

4. TITLE AND SUBTITLE
Fish Bioacoustics - Sensory Biology, Behavior and Practical Applications - An International Symposium

5. FUNDING NUMBERS
N00014-01-0147

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
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8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Office of Naval Research
800 N. Quincy Street
Arlington, VA 22217-5000

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Distribution Unlimited

20020610 112

13. ABSTRACT *(Maximum 200 words)*

This grant helped fund an international scientific meeting titled "Fish Bioacoustics: Sensory Biology, Behavior and Practical Applications" on May 30 - June 2, 2001, at Evanston, Illinois. The purpose was to bring together investigators interested in all basic and applied aspects of fish bioacoustics to present material and share ideas. Participating were experts on all aspects of fish bioacoustics, including basic scientists in biology, psychology, and evolutionary biology, underwater acousticians, consultants, acoustics engineers, National Marine Fisheries Service scientists, and others with related expertise to establish what we know about hearing, sound production, acoustic communication and other behaviors of fishes with respect to man-made and other biological and non-biological sounds in their environments. The long-term goal was to more completely understand the acoustic biology of fishes and its relations to human activities and concerns. The conference was successfully held. Over 100 scientists participated. A paper from each participant will be published in a special issue of the journal Bioacoustics in 2002.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Underwater sound, fish, sonar, noise	5
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
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FINAL REPORT

GRANT #: N00014-01-1-0147

PRINCIPLE INVESTIGATOR: Dr. Richard R. Fay

INSTITUTION: Loyola University Chicago

GRANT TITLE: Fish Bioacoustics, An International Symposium

AWARD PERIOD: 01/01/2001 - 12/31/2001

OBJECTIVE: This grant helped fund an international scientific meeting titled "Fish Bioacoustics: Sensory Biology, Behavior, and Practical Applications" on May 30 -June 2, 2001, at Evanston, Illinois.

APPROACH: The purpose of the meeting was to bring together about 100 investigators interested in all basic and applied aspects of fish bioacoustics to present material, share ideas, and, most importantly, learn from, and develop an understanding of, the questions and approaches taken by one another. The conference was designed to foster these interactions, and help investigators with widely different research interests come together to foster research interactions. Long-term goals of the conference were to educate those in the field who don't normally interact professionally, and to help establish collaborations among investigators across disciplines and research fields.

Attending were experts on all aspects of fish bioacoustics, including basic scientists in biology, psychology, and evolutionary biology, underwater acousticians, consultants, acoustics engineers, National Marine Fisheries Service scientists, and others with related expertise to establish what we know about hearing, sound production, acoustic communication and other behaviors of fishes with respect to man-made and other biological and non-biological sounds in their environments. The goals were to educate scientists in the various basic and applied disciplines relating to fish bioacoustics, and to foster the development of scientific collaborations among those basic and applied workers. The long-term goal was to more completely understand the acoustic biology of fishes and its relations to human activities and concerns.

ACCOMPLISHMENTS: The conference was successfully held at the scheduled time and place. Over 100 scientists participated. Below in PUBLICATIONS AND ABSTRACTS is the program. These titles will be published in a sspecial issue of the journal *Bioacoustics* later in 2002.

CONCLUSIONS: A major goal of the conference was to facilitate interdisciplinary discussions that will lead to the development of novel perspectives and integrated approaches to pure and applied problems in fish bioacoustics. Some of these applied questions include: What fundamental aspects of the biology of sensory systems must be understood in order to appropriately address questions of environmental and human concern, including: how sound is used to assess fish populations, how to avoid impingement of fishes in power plants and irrigation facilities, how to design dams and bypasses to accommodate normal migratory fish behavior, how to assess the effects of seismic surveys on fish behavior, and physiology? These and many other

questions were approached and discussed at the meeting and in the subsequent publications.

SIGNIFICANCE: Underwater sounds from ship noise, sonar, seismic exploration, and other man-made sources may affect the normal behavior and health of fishes in the world's oceans and lakes, and may impact commercial fisheries. The field of fish bioacoustics encompasses work by scientists with interests in basic biology, including structure, function, and evolution of the auditory and mechanosensory lateral line systems, as well as those with interests in applied areas, such as the use of sound for the assessment of fish populations, the effects of intense sound on fish behavior. This symposium was designed to help provide a set of rational approaches to research that could determine whether and to what extent such noise could affect fishes and their biology. The publications arising from the conference will serve as a complete guide to the field (see below in PUBLICATIONS AND ABSTRACTS).

PATENT INFORMATION: none

AWARD INFORMATION: Promoted to Director, Parmly Hearing Institute, Loyola University Chicago

PUBLICATIONS AND ABSTRACTS: This program reflects written contributions by each set of authors that will be published as a special issue of the journal *Bioacoustics*, to be published later in 2002.

9:30 Fish Bioacoustics: A Personal History -- William N. Tavolga
9:55 Structure-Function Relationships in the Ears of Fishes -- Arthur N. Popper
10:50 The Sense of Hearing in Fishes -- Richard R. Fay
11:15 Variations on a Vertebrate Theme: Central Anatomy of the Auditory System in Fish -- Catherine A. McCormick
11:40 Evolution of the Octavolateralis System: A Phylogenetic Assessment -- Christopher B. Braun, Terry Grande
1:35 Functional Evolution of the Lateral Line System - J. F. Webb
2:00 Otoliths And Modeling Of Inner Ear Function -- Dmitri V. Lychakov, Yuri T Rebane
2:50 Is the Fish Ear an Auditory Retina? Minami Yoda, Peter H. Rogers, Kathryn E. Blaxter
3:10 Development of the Fish Auditory System: How do Changes in Auditory Structure Affect Function? Dennis M. Higgs
4:10 Anthropogenic Sound and Fish -- Arthur N. Popper
4:35 Natural History in an Unnatural Environment: Can We Help Fish to Help Themselves? -- Carl R. Schilt

Poster Sessions

1. The Role of Acoustic Signals in Domino Damselfish (*Dascyllus albisella*) Mate Choice -- Steven J. Oliver, Phillip S. Lobel
2. Acoustic Signals and Aggressive Conflicts in the Skunk Loach (*Botia morleti*): Integrating Sensory and Behavioral Approaches -- Timothy C. Sparkes, Hong Y. Yan, Callie Prater, Tomonari Akamatsu
3. Calls of the Atlantic Cod: Characteristics and Variations with Time, Season and Temperature -- Kjell Midling, Aud Vold Soldal, Jan Erik Fosseidengen, Jan Tore Øvredal
4. Intra and Inter-Day Variability in Sound Production by Red Drum (Scianidae) at a Spawning Site -- Scott A Holt

5. Use of Sound for Localization of Spawning Weakfish in Delaware Bay and Effects of Fish Size, Temperature and Season on Sound Parameters -- Martin A. Connaughton, Michael L. Fine, M. Taylor
6. The Single Sonic Muscle Twitch Model for Sciaenid Sound Production -- Mark W. Sprague
7. Patterns and Processes of Mating in Atlantic cod -- Sherrylynn Rowe, Jeffrey A. Hutchings
8. Soniferous Behavior of the Striped Cusk-Eel, *Ophidion marginatum*, and Other Coastal Marine Fishes Based on Preliminary Laboratory and Field Observations - R. A. Rountree, J. Bowers-Altman
9. Sounds of Western North Atlantic Fishes - Data Rescue -- Rodney A. Rountree, Paul J. Perkins, Robert D. Kenney, Kenneth R. Hinga
10. Acoustic Excitation of the Fish Swimbladder -- David Francis, Kenneth Foote.
11. Experiments for Possible Hydroacoustic Discrimination of Free-Swimming Juvenile Gadoid fish by Analysis of Broadband Pulse Spectra as well as 3D Fish Position from Video Images and Split Beam Acoustics -- Bo Lundgren, J.Rasmus Nielsen
12. Estimation of the Target Strength of Fish from Acoustic Models and Comparison with In-Situ Estimates -- Gavin J. Macaulay
13. Responses of Primary and Secondary Lateral-Line Units to Dipole Stimuli Under Still and Running Water Conditions -- Jacob Engelmann, Sophia Kröther, Joachim Mogdans, Horst Bleckmann
14. Boundary Layer Flow Along Swimming Fish and its Implications for Lateral Line Excitation -- Mark A. Grosenbaugh, Erik J. Anderson
15. Directional Orientation to Reef Sound By Pre-settlement Reef Fish Larvae -- Olivia S. Haine, Nicholas Tolimieri' John C. Montgomery
16. Analyses of Small Tank Acoustics: Empirical and Theoretical Approaches -- Tsuyoshi Okumura, Tomonari Akamatsu, Hong Y. Yan
17. Preliminary Evidence on the Use of Sound to Decrease Losses of Aquatic Organisms at a Power Plant Cooling Water Intake -- Arthur N. Popper, John Balletto, Kenneth Strait, Fred Winchell, Alan Wells, Maureen Vaskis
18. The Distribution Of The Unconventional Myosins In The Zebrafish Ear -- Allison B. Coffin, Arthur N. Popper
19. Amiloride and DHSM similarly change hair cell bundle mechanics -- J.E.C. Wiersinga-Post, Sietse M. Van Netten
20. The Effects of Noise on Auditory Sensitivity of Fish -- Amy R. Scholik, Hong Y. Yan
21. Potential Means of Ultrasound Source Localization in Herrings -- Carl R. Schilt, Charlie Escher.
22. Examination of Underwater Hearing and Frequency Discrimination in the Clawed Frog, *Xenopus laevis laevis* -- Andreas Elepfandt
23. Modeling Studies and Physiology of Discriminatory Coincidence Detection in the Mauthner Neuron -- Janet L. Casagrand, Graham I. Cummins, Robert C. Eaton
24. A Physical Analysis of the Sound Fields that Trigger Acoustic Escape in Fishes -- Graham I. Cummins, Janet L. Casagrand, Robert C. Eaton
25. Response of Goldfish Otolithic Afferents to a Moving Dipole Sound Source -- Richard R. Fay, Sheryl Coombs, Andreas Elepfandt
26. Neural representations of acoustic particle motion direction in the midbrain of the goldfish, *Carassius auratus* -- Wei-Li D. Ma, Richard R. Fay

27. An In Vitro Whole Brain Preparation Of Fishes for the Electrophysiological Analysis of Sensory Pathways -- Michaela Meyer, Dennis T. T. Plachta, Arthur N. Popper, Horst Bleckmann
28. Evolution of the Weberian Apparatus -- Terry Grande, Christopher B. Braun
29. Unique Swim Bladder Anatomy of Silver Perch, *Bairdiella chrysoura*, and its Possible Implications -- John Ramcharitar
30. Otolithic Endorgan Projections of the Inner Ear in a Vocal Fish -- Joseph A. Sisneros, Margaret A. Marchaterre, Andrew H. Bass,
31. Structural and Functional Evidence for Acoustic-Lateral Line Interactions in a Vocal Fish -- Matthew S. Weeg, Andrew H. Bass
32. Ontogeny of Hearing and Sound Production in Fishes -- Lidia E. Wysocki, Friedrich Ladich
33. Correlation of Sound Production with Hearing Sensitivity and Behavior in the Lake Malawi Cichlid, *Tramitichromis intermedius*. Jennifer L. Ripley, Phillip S. Lobel, Hong Y. Yan
34. A Remote-Controlled Instrument Platform for Fish Behaviour Studies and Sound Monitoring -- Ingvald Svellingen, Bjørn Totland, Jan Tore Øvredal
35. Passive Hydrophone Census of *Sciaena umbra* (Sciaenidae) in the Gulf of Trieste (Northern Adriatic sea, Italy) -- Clizia Bonacito, Marco Costantini-, Marta Picciulin, Enrico A. Ferrero, Anthony D. Hawkins
36. Sound Emissions of the Mediterranean damselfish *Chromis chromis* (Pomacentridae) Marta Picciulin, Marco Costantini , Anthony D. Hawkins, Enrico A. Ferrero
37. Discriminating Between Fish Sounds - A Wavelet Approach -- Mark Wood, Licia Casaretto, Graham W. Horgan, Anthony D Hawkins

8:05 Locating Spawning Haddock by Means of Sound -- Anthony D Hawkins , Licia Casaretto, Marta Picciulin

8:25 Diversity of fish courtship and spawning sounds and the application of acoustic technology for monitoring reproduction -- Phillip S. Lobel

8:50 Using Passive Acoustics to Monitor Estuarine Fish Populations -- Joseph J. Luczkovich, Mark W. Sprague

9:10 Acoustical Neural Telemetry from Free Swimming Fish -- Allen F. Mensinger', Max Deffenbaugh

9:30 The Use of Acoustically Evoked Potentials for the Study Of Enhanced Hearing in Fishes -- Hong Y. Yan

9:55 An Underwater End Game: Dolphin Ears as Fish Finders -- Darlene Ketten

11:00 Ultrasound Perception in Fish, an Old Question -- Per S. Enger

11:25 Ultrasound Detection by Clupeiform Fishes -- David A. Mann, Dennis M. Higgs, William N. Tavolga, Arthur N. Popper

1:25 Imaging of the Hydrodynamic Environment by the Peripheral Lateral Line System -- Sheryl Coombs

1:50 Lateral-Line Reading of Hydrodynamic Frequency Dispersal of Water Surface Waves: Parallels to Auditory Mechanics -- Andreas Elepfandt

2:10 Relation Between Mechanical and Electrical Frequency Selectivity of Peripheral Signal Processing by the Lateral Line Organ -- Sietse M. Van Netten, J. Esther C. Wiersinga-Post

2:40 Mitigating Seismic Impact On Marine Life: Current Practice And Future Technology. Max Deffenbaugh

3:00 Effects of Seismic Shooting and Vessel-Generated Noise on Fish Behaviour and Catch Rates -- Arill Engås, Svein Løkkeborg

3:25 Behavioral, Physiological And Pathological Response Of Selected Fishes To Nearby Air-Gun Noise -- Robert D. McCauley, Jane Fewtrell

8:05 Acoustic Scattering by Swimbladdered Fish: A Review -- Kenneth G. Foote, David T. I. Francis

8:25 Innovative uses of Fisheries Acoustics in the Northwest Atlantic -- J. Michael Jech

8:50 Hydroacoustic Assessment of Fish Numbers, Sizes and Distribution in Lakes and Rivers -- Frank Reier Knudsen

9:15 Bioacoustic Absorption Spectroscopy: A New Approach to Estimation of Biomass -- Orest Diachok

9:40 Acoustic Scattering Models of Zooplankton -- Andone C. Lavery , Timothy K. Stanton

10:40 Fish Bioacoustics and Behavior -- Arthur A. Myrberg, Jr.

11:05 The Evolution of Sound Production in Fishes: phylogenetic distribution and functional significance of multiple mechanisms -- Ingrid M. Kaatz

11:30 Did auditory sensitivity and sound production evolve independently in fishes? Friedrich Ladich

1:30 Acoustic Communication and Auditory Neural Computation in Sound-Producing Fish -- John D. Crawford

1:55 Neural and Endocrine Regulation of Vocal-Acoustic Networks -- Andrew H. Bass

2:20 Bioenergetics of Calling in Oyster Toadfish, *Opsanus tau.* -- Clara P. Amorim, Marti L. Mccracken, Michael L. Fine

2:40 Movement and Sound Generation By The Toadfish Swimbladder -- Michael L. Fine, Karl L. Malloy , Charles Brian King, Steve Mitchell, Timothy M. Cameron

3:30 Gobies as a model for the study of fish acoustic communication -- Marco Lugli

3:55 The significance of the sounds of males of *Bathygobius curacao* to conspecific females: similar findings to a study made long ago -- Arthur A. Myrberg, Jr., John H. Stadler

4:15 Spawning behavior and the acoustic repertoire of haddock -- Licia Casaretto, Anthony D Hawkins

8:35 Sound Source Localization: An Historical Assessment -- Olav Sand

9:00 Directional Auditory Processing by the Oyster Toadfish, *Opsanus tau* -- Peggy L. Edds Walton, Richard R. Fay

9:25 Roles of the Saccule in Directional Hearing -- Zhongmin Lu, Zemin Xu, John Stadler

9:50 Neural Implementation of the Phase Model for Localization of Impulse Sounds by the Mauthner System -- Robert C. Eaton, Janet L. Casagrand, Graham I Cummins

10:15 Ambient Sound as a Navigational Clue For Larval Reef Fish -- John C. Montgomery, Nicholas Tolimieri, Olivia Haine